Beaver Creek Drainage
Biological and Water Quality Investigation

Kentucky Department for Environmental Protection
Division of Water
Biological Section

Technical Report No. 10

Frankfort, Kentucky

This report has been approved for release:

/s/ Donald F. Harker

Donald F. Harker, Director
Division of Water

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Beaver Creek
Biological and Water Quality Investigation
for Stream Use Designation

For

Division of Water

By

Biological Branch
Division of Environmental Services

Technical Report No. 10

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Abstract

A biological and water quality investigation of the Beaver Creek subbasin (segment 02007) of the Cumberland River basin was conducted in June, 1982 to determine the existing water quality, aquatic uses, causes of impairments to aquatic uses and what aquatic uses can be attained, based on the physico-chemical and biological characteristics of the segment.

The Beaver Creek subbasin lies in portions of the Appalachian Plateaus Province and bordering Interior Low Plateaus Province, in Wayne County, Kentucky. The major impacts to the streams of this segment are domestic wastewater and agricultural runoff. Stream uses in the segment include primary contact recreation, as well as coldwater and warmwater sport fishing. Violations of Kentucky Surface Water Standards for phthalate esters, aluminum, mercury, free cyanide and fecal coliform bacteria were observed. However, data from this survey did not indicate a significant adverse impact to the aquatic biota. It is recommended that the segment be designated for Aquatic Life/Warmwater Aquatic Habitat, as well as Primary and Secondary Contact Recreation. In addition, it is recommended that a portion of Beaver Creek, stocked with trout by Kentucky Fish and Wildlife Resources, be designated for Aquatic Life/Coldwater Aquatic Habitat. Data from this study indicate that these uses are currently occurring, or are attainable with the application of appropriate point source control technology.

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Recommendations

1. Based on the diversity of the aquatic biota, it is recommended that Beaver Creek subbasin (segment 02007) be designated for Aquatic Life/Warmwater Aquatic Habitat per 401 KAR 5:031, Section 5 (1) and the criteria of that section be applied without modification throughout the segment.
2. Based on the ability of the stream to support a known trout fishery, it is recommended that Beaver Creek, from RMI 29.4 to 34.2, be designated for Aquatic Life/Coldwater Aquatic Habitat per 401 KAR 5:031, Section 5 (2) and the criteria of that section be applied without modification for this portion of the stream.
3. Based on the fecal coliform and pH data, it is recommended that segment 02007 be designated for Primary and Secondary Contact Recreation per 401 KAR 5:031, Section 7 (1) (2) and the criteria of that section be applied without modification throughout the segment.
4. Neither Beaver Creek nor any of its tributaries are used for a public drinking water supply; therefore, it is not recommended for the domestic water supply drinking water use classification.

Summary

1. The Beaver Creek subbasin (including tributaries) in Wayne County constitutes a single segment (02007) within the upper Cumberland River basin.
2. The major impacts to the Beaver Creek segment are discharges of municipal wastewater and agricultural runoff.
3. Stream uses in the segment include warmwater aquatic habitat, coldwater aquatic habitat, and primary and secondary contact recreation.
4. No public water supply withdrawals are known to occur within segment 02007.
5. Violations of Kentucky Surface Water Standards (401 KAR 5:031, Section 5 (1)) were observed for free cyanide, phthalate esters, aluminum, and mercury.
6. Fecal coliform bacteria criteria for Primary Contact Recreation, 401 KAR 5:031, Section 7 (1) were violated at one of the four sampling locations (7-1) during this survey.
7. An excellent diversity of aquatic organisms was observed in this study, which is an indication of good water quality and habitat diversity. A total of 192 algal taxa, 127 taxa of macroinvertebrates and 15 species of fish were identified.

INTRODUCTION

The Beaver Creek subbasin lies within Wayne County, Kentucky. This drainage, including its major tributaries, Elk Spring Creek and Duncan Branch, from the headwaters to the confluence with Lake Cumberland (Beaver Creek RMI 21.0) constitutes a single segment. This segment is designated as 02 (Cumberland River Basin) 007 (Beaver Creek segment).

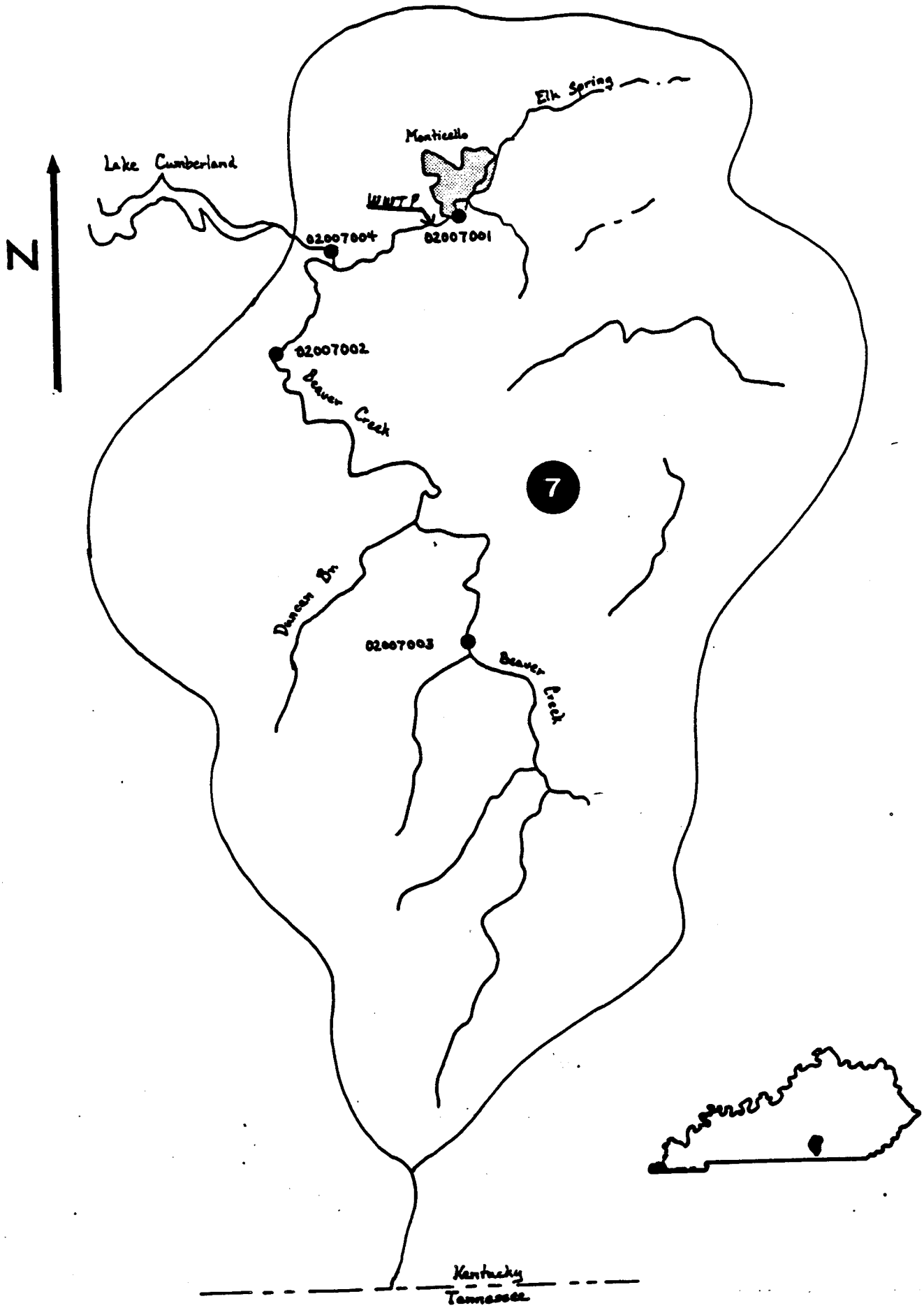
A survey of the Beaver Creek basin was undertaken by the Kentucky Department for Environmental Protection (DEP) in June 1982. Four sampling stations were established in the drainage (Figure 1) and sampled once during a low flow period. The location of these stations, dates sampled and parametric coverage are given in Appendix A. The purposes of this investigation were as follows:

1. To determine the existing water quality of the basin.
2. To determine the aquatic uses currently being achieved in the drainage.
3. To determine the causes of any impairments of the aquatic uses.
4. To determine what aquatic uses can be attained based on the physical, chemical and biological characteristics of the watershed.

Literature Review

Physicochemical data for Beaver Creek consist of flow, conductivity and water temperature collected since 1968 by the United States Geological Survey (USGS 1982). The U. S. EPA conducted an eutrophication study on Lake Cumberland in 1973 (U. S. EPA 1977), which included nutrient data from the Beaver Creek embayment (Station 7-4). Biological data are limited to fish studies conducted by Carter and Jones (1969) and the Kentucky Nature Preserves Commission (Warren et al. 1983) and two mussel studies (Wilson and Clark 1914 and

Figure 1
Map of Beaver Creek Segment with Sampling Locations



Neel and Allen 1964) that took place in Beaver Creek, near the mouth, prior to the impoundment of Lake Cumberland.

Basin Impacts

There are four permitted dischargers (Table 1) listed in the Division of Water (DOW) Facility File, with the city of Monticello WWTP (pop. 5,677) being the largest. Agricultural land makes up 87% of the segment (Mayes, Sudderth and Etheridge 1975) and runoff from these areas may also be a major impact. In addition, approximately 10% of the basin is utilized for silviculture, which may provide an additional impact, particularly from siltation. At one time, oil drilling operations had an impact on the stream, but most of these facilities are not operating at the present time. Discussion with local residents indicates that oil well drilling and storage operations have impacted the creek in the past.

According to the 201 facility plan, the Monticello WWTP will be expanded from the existing 0.336 mgd to 0.7 mgd. The new plant will employ an oxidation ditch at the existing site to treat Monticello's municipal waste. The discharge point will be relocated from mile point (mp) 1.5 on Elk Spring Creek to near the confluence of Elk Spring and Beaver Creek (a total distance of 1.1 mi), where it becomes inundated by Lake Cumberland. The new discharge permit will require that the effluent meet 30.0 mg/l suspended solids (SS), 30.0 mg/l biochemical oxygen demand (BOD), 4.0 mg/l (10 mg/l winter) ammonia nitrogen, and 7.0 mg/l dissolved oxygen.

Table 1
Beaver Creek Permitted Dischargers

Facility #	Facility Name	Design Flow GPD	Receiving Stream	Mile Point
02007001	Monticello, city of WWTP	336,000	Elk Spring Creek	1.5
02007002	Mago Construction Co.	no discharge	-	-
02007003	KOA Campground	10,000	U.T. (sinking stream)	-
02007004	National Guard Armory	1,200	sinkhole	-

Stream Uses

Beaver Creek receives considerable fishing pressure, especially for rainbow trout (Carter and Jones 1969, Sehlinger and Underwood 1980). Although no primary contact recreation was observed during this survey, it can be assumed that those activities occur.

Hunting for waterfowl, small mammals and deer occur throughout the watershed in rural areas. Those game animals, as well as non-game species, utilize the various streams and adjacent buffer zones for breeding, rearing young and feeding, as well as a water supply for drinking. Trapping, principally for small mammals, such as muskrats, mink, etc., also occurs in rural sections of the drainage.

METHODS

Water samples were analyzed in accordance with the latest edition of Standard Methods for the Examination of Water and Wastewater (APHA 1981) and United States Environmental Protection Agency's (U. S. EPA) Methods for Chemical Analysis of Water and Waste (U. S. EPA 1979). Field turbidity measurements were taken with an HF Instruments Model DRT-15 turbidimeter. Field conductivity was determined with a Yellow Springs Instrument Company (YSI) Model 33 S-C-T meter. Field measurements for dissolved oxygen (DO) and water temperature were conducted with a YSI Model 54A oxygen meter. An Analytical Measurements Model 707B pH meter was used for field pH.

Stream gradient was classified as either low (0 to 5 ft/mi), moderate (5 to 20 ft/mi) or high (greater than 20 ft/mi). Gradient was determined by the methods outlined in DES (1983).

Biological samples were collected utilizing a variety of techniques. Qualitative algal samples were procurred by selectively scraping or suctioning material from all available habitats. Samples were preserved in the field with 5% buffered formalin and transported to the Division of Environmental Services (DES) biological laboratory for analysis. Diatoms were treated with 30% hydrogen peroxide and potassium dichromate to remove organic material (van der Werff 1955), and several slides randomly scanned for the presence of rare taxa.

Macroinvertebrate qualitative samples were taken by selectively picking various substrate types and by collecting in different habitats with a triangular kick net. Quantitative samples were collected using a modified Hornig and Pollard (1978) travel-kick method. Three replicates were collected with a 0.045 m^2 triangular kick net over a 10 ft area for 60 seconds. All macroinvertebrate samples were preserved in the field in 70% alcohol solution and transported to the DES biological laboratory for enumeration and identification.

The trophic relationships follow those outlined by Merritt and Cummins (1978) and Hawkins and Sedall (1982). Aquatic macroinvertebrates were placed into one of three pollution categories, (i.e. tolerant, facultative and intolerant), generally based on information presented by Weber (1973) and Hart and Fuller (1974). These categories are defined by Beck (1955) and Weber (1973) as follows: tolerant organisms are associated with gross organic contamination and are generally capable of thriving under anaerobic circumstances; facultative organisms are capable of tolerating a wide range of environmental conditions, including moderate levels of organic enrichment, but cannot exist under anaerobic conditions; intolerant organisms are sensitive to even moderate levels of organic enrichment and are generally unable to withstand even moderate reductions of dissolved oxygen.

Diatom and macroinvertebrate species diversity indices ($\bar{d}$) and equitability (e) were calculated using the procedure described by Weber (1973). Diatom relative abundance, $\bar{d}$ and e, was generated by counting a minimum of 500 valves. Macroinvertebrate relative abundance was calculated with the pooled quantitative data.

Fish were collected using a 3.4 m by 1.2 m, 0.3 cm mesh, common sense minnow seine. Pool, riffle areas and all other recognizable habitat types were sampled. The fish samples were preserved in 10% formalin solution and transported to the DES biological laboratory for enumeration and identification. Fish community structure was analyzed using the methods of Karr (1981).

Bacteriological samples were collected from directly below the water's surface in 250 ml, wide mouth, sterile nalgene jars, placed on wet ice and returned for analysis to the DES biological laboratory within six hours. Analyses for fecal coliform and fecal streptococcocus bacteria were performed using the membrane filter techniques outlined by Bordner, Winter and Scarpino (1978).

PHYSICAL EVALUATION

Beaver Creek, originally a fourth order stream, had a total length of 62.5 km (38.8 mi). Originating in southcentral Wayne County, it flows north to join the Cumberland River (Lake Cumberland) at RMI 466.7, in Russell County. The lower 33.8 km (21 mi) of Beaver Creek are inundated by Lake Cumberland and are not included in this segment (02007). Therefore, Beaver Creek is a third order stream within this segment. Major tributaries include Elk Spring Creek and Duncan Branch. In addition, there are several sinking streams in the segment. Drainage area for the segment includes 238 km^2 (92 mi^2), of which 120 km^2 (46.5 mi^2) are in the Elk Spring Creek drainage (Bower and Jackson 1981).

The headwaters of this subbasin originate in rugged, highly dissected uplands at an elevation of 1060 ft above mean sea level (msl) on the Cumberland Plateau, a section of the Appalachian Plateaus Province (Quarterman and Powell 1978). As it flows north, the stream traverses part of the Eastern Highland Rim and enters into the Cumberland Enclave (both are subsections of the Highland Rim - a portion of the Interior Low Plateaus Province) (Quarterman and Powell 1978). The Highland Rim is very dissected on both sides of the Cumberland River, leaving steep-sided hills and knobs extending five to 20 miles from the river (Quarterman and Powell 1978). The elevation of Beaver Creek at RMI 21.35, where it becomes inundated by Lake Cumberland, is 740 ft above msl. The average gradient to this point is 3.4 m/km (18 ft/mi). The average gradient for Elk Spring Creek is 7.9 m/km (42 ft/mi). The two major soil groups and their characteristics are given in Table 2.

The USGS has maintained a gaging station on Beaver Creek (RMI 24.0) from 1968 to the current year. Flow data through 1981 recorded by this station, shows an average discharge of 1.96 m^3/s (69.1 ft^3/s), a maximum discharge of 262 m^3/s (9,240 ft^3/s) on December 9, 1978 and a minimum discharge of 0.014

Table 2
Soils of the Beaver Creek Basin

Soil[1] Association	Slope[2] %	Drainage[2] Class	Potential[1] Sediment Runoff	Infiltration[1]	Septic Tank Absorbtion Rating
Cumberland	2-10	well drained	Medium	Medium	Moderate
Pembroke	2-12	well drained	Low	Medium	Slight
Talbott	6-20	essentially well drained			
Frederick	6-12	-	Medium	Medium	Moderate
Talbott	6-20	essentially well drained	High	Very slow	Severe

(1) Mayes, Sudderth and Etheridge (1975)
(2) Bailey and Winsor (1964)

m^3/s (0.50 ft^3/s) on October 2, 1968 (USGS 1982). Mayes, Sudderth and Etheridge (1975) indicated that a large spring in Monticello (formerly the community water supply) may provide low-flow augmentation during the 7-day, 10-year design period. The USGS also has a partial-record gaging station located on Elk Spring Creek (RMI 7.1). Data from this station for the period of record (1976-1981) shows an annual maximum discharge ranging from 1.95 m^3/s (69 ft^3/s) on March 21, 1980 to 4.02 m^3/s (142 ft^3/s) on June 6, 1981 (USGS 1982).

Stream habitats noted in Elk Spring Creek and Beaver Creek were diverse and generally well developed. Pools alternating with riffles were common, except at station 7-4, which is periodically impounded by Lake Cumberland. Undercut banks, rock ledges, large boulders and submerged tree roots existed at all sites as well as a variety of substrates. Riparian zones were covered with a variety of trees, shrubs and herbaceous plants (38 species were noted, Appendix B). Overhanging trees shaded parts of Elk Spring and Beaver creeks. The buffer zones

aided in stabilizing creek banks and minimizing erosion. They also served as traps for sediments and nutrients in surface runoff, as well as food and cover for invertebrates, fish and wildlife. Studies indicating the importance of riparian vegetation to fauna and to stream water quality include Karr and Schlosser (1978), Nelson et al. (1978), Schlosser and Karr (1981) and Johnson and McCormick (1978).

The following is a brief description of the sampling stations. More detailed information is given in Appendix A.

Elk Spring Creek

Station 02007001 (7-1)

Physicochemical sampling was conducted at the KY 167 bridge, in Monticello. The stream here is third order with high gradient. The surrounding area includes the City of Monticello. A pipe was observed leading from the adjacent house on the south side of the stream to the creek. Trees covered the north bank areas, while grasses and shrubs were predominant over the south bank. Pools alternated with riffles and a diversity of other stream habitats were present. The substrate was primarily bedrock in the pools and cobble/pebble in the riffles.

Beaver Creek

Station 02007002 (7-2)

This site was located at the KY 200 bridge in southwestern Wayne County. The stream is third order with moderate gradient. The adjacent land area was predominantly forested with limited agriculture. Trees covered most of the southwest bank. Scattered buildings and an oil storage facility existed beyond the northeast bank; the riparian zone here was modified to shrubs and grasses. Several riffles occurred in areas of cobble/boulder substrate, but the primary substrate was bedrock under long, shallow runs.

Beaver Creek

Station 02007003 (7-3)

This station was located at a ford off KY 167 in southwestern Wayne County. The creek here is third order with high gradient. Farm fields and wooded hillsides were common in the area. Both banks were tree lined and varied in slope from 20 to 60%. A diversity of habitats was present in the stream; pools and riffles were common. Substrates were primarily pebble/gravel in the pools and pebble in the riffles.

Beaver Creek

Station 02007004 (7-4)

Physicochemical samples were taken from the KY 90 bridge in western Wayne County. The stream is third order with moderate gradient and flows through a deep gorge. Due to the lack of access to Beaver Creek at this site, no biological sampling was conducted. Forested hillsides surrounded the area and extended to the stream's upper bank. The substrate was primarily bedrock.

PHYSICOCHEMICAL EVALUATION

A total of 58 physicochemical parameters (Table 3) were analyzed from surface grab samples taken at four locations during this study. Conductivity and water temperature data have been collected by the United States Geological Survey (USGS) since 1968 (USGS 1982). The physicochemical data from this study indicate that the Beaver Creek system above Elk Spring Creek is a high quality, well buffered, hardwater stream.

Conductivity, total dissolved solids (TDS), total alkalinity and total hardness values were comparable to those from other high quality streams draining limestone stratas in the upper Cumberland River basin, according to data presented by Harker et al. (1979 and 1980), Dyer (1982) and USGS (1982). Conductivity was within the range (150 to 500 umhos/cm) reported by Ellis (1937) as capable of supporting a diverse fish fauna. The TDS was considerably less than the upper limit of 2000 mg/l which inhibits fish spawning as reported by McCarraher and Thomas (1968). Values for conductivity and TDS at 7-2 were slightly elevated over that observed at the other stations. This was possibly due to surface or subsurface runoff from an old oil storage area that lies adjacent to the creek at this sampling location.

There were no violations of Kentucky Surface Water Standards for dissolved oxygen (DO) or pH at any site. Biochemical oxygen demand (BOD) and chemical oxygen demand (COD) were not considered limiting to aquatic organisms at any location (Table 3).

Neither sulfate ($SO_4^{=}$) nor chloride (Cl^-) violated Kentucky Surface Water Standards (401 KAR 5:031, Section 6) (Table 3) and both were below STORET (1979-1982) mean values (60.5 mg/l and 21.5 mg/l, respectively). However, values at 7-2 showed a slight increase over those observed at the remaining stations. As mentioned previously, this was probably due to surface and/or subsurface drainage from an old oil storage area that is adjacent to 7-2.

Except for nitrite + nitrate-nitrogen (NO_2+NO_3-N), the nitrogen series values (Table 3), i.e. ammonia-nitrogen (NH_3-N) and total Kjeldahl nitrogen (TKN), were similar to STORET (1979-1982) mean values of 0.23 mg/l (NH_3-N) and 0.64 mg/l (TKN). The NO_2+NO_3 -N values exceeded the mean STORET (1979-1982) value (0.69 mg/l) at all sampling locations. The highest NO_2+NO_3-N values were observed in Elk Spring Creek (7-1), which flows on the eastern and southern edge of Monticello, and at station 7-4, which was the most downstream station on Beaver Creek and approximately 2.4 km below the Monticello WWTP. Both point and nonpoint sources, from Monticello and the surrounding area, apparently account for the elevated NO_2+NO_3-N values at these stations. Patrick (1950) noted that healthy streams in the eastern United States should not exceed 2.0 mg/l nitrate. Station 7-1 exceeded Patrick's (1950) value and station 7-4 approached it.

As was observed for NO_2+NO_3-N, total phosphorous values at stations 7-1 and 7-4 were also elevated over those observed at the remaining two stations (Table 3). Only station 7-4 approached the STORET (1979-1982) mean value (0.16 mg/l). Concentrations in flowing waters are generally below 0.1 ppm (NTAC 1968, Keup 1968), except in streams receiving agricultural runoff (Omernik 1977) and domestic wastewater (Wetzel 1975). Only station 7-4 exceeded this value. Depending on the pool storage volume of Lake Cumberland, both Beaver and Elk Spring creeks may discharge directly to the reservoir. To prevent the development of biological nuisances and to control accelerated eutrophication, the U. S. EPA (1976) recommends that total phosphates as phosphorous (P) should not exceed 50 ug/l in any stream at the point where it enters any lake or reservoir, or 25 ug/l within the lake or reservoir. Streams or other flowing waters that do not discharge directly into lakes or reservoirs should not exceed 100 ug/l total P (Mackenthun 1973). Most relatively unpolluted lake districts are known to have surface waters that contain from 10 to 30 ug/l total phosphorous as P (Hutchinson 1957). The total

phosphorous values at station 7-4 exceeded the recommended U. S. EPA (1976) value by a factor of two. This is of particular concern since station 7-4 is at the upper end of the Beaver Creek embayment of Lake Cumberland. Since phosphorous is usually the nutrient most limiting to primary production (Wiebe 1931, Schindler 1971), and increased amounts generally accelerate eutrophication (Winger 1981), then the Beaver Creek embayment may be subject to increased eutrophication processes.

Violations of Kentucky Surface Water Standards for free cyanide (CN), 401 KAR 5:031, Section 5 (1)(h)(3), of 5 ug/l were observed at stations 7-1 and 7-4. Cyanide compounds, which are used and readily formed in many industrial processes are commonly found in a variety of effluents (U.S. EPA 1981a). The toxicity to aquatic organisms of most simple cyanide and metalocyanid complexes is due mainly to the presence of HCN (Doudoroff et al. 1966, Smith et al. 1979). The CN ion (CN^-) is also toxic to aquatic life (Broderius et al. 1977). Generally, the complex ions themselves have relatively low toxicity (U.S. EPA 1980a). Cyanide toxicity increases with a reduction of dissolved oxygen below the saturation level (Doudoroff 1976, Smith et al. 1978). Water temperature and pH may also effect the toxicity of CN (U. S. EPA 1980a). The U. S. EPA (1980a) recommended criterion for free CN to protect freshwater aquatic life is 3.5 ug/l as a 24 hr average, and the concentration should not exceed 52 ug/l at any time.

Phthalate esters exceeded the Kentucky Surface Water Standard (3.0 ug/l) for warmwater aquatic habitat at three of the four sampling locations (7-1, 7-2 and 7-3) (Table 3). According to U. S. EPA (1980b) phthalate concentrations as low as 940.0 ug/l can be acutely toxic to freshwater aquatic life and chronic toxicity may occur at levels as low as 3.0 ug/l for more sensitive aquatic species.

Kentucky Surface Water Standards for aluminum (Al) 401 KAR 5:031, Section 5 (1)(h)(2) and mercury (Hg), 401 KAR 5:031, Section 5 (1)(h)(3) were

violated at all sites. The Al and Hg standards violations are of concern, since both of these metals are known to bioaccumulate (Phillips and Russo 1978), and are known to be toxic to aquatic organisms in low concentrations (refer to Birge et al. 1978 and U. S. EPA 1980c).

Table 3: Physicochemical data for the Beaver Creek Drainage

Parameter	7-1	7-2	7-3	7-4
Conductivity (umhos/cm @ 25°C)	394	485	281	423
pH	7.7	7.7	7.7	7.9
Air temperature (°C)	27.0	21.1	26.6	ND
Water temperature (°C)	17.4	21.2	21.9	21.8
Turbidity (NTU)	6.0	6.5	7.5	9.0
DO (mg/l)	9.3	9.4	9.2	9.4
Acidity (mg/l)	10.4	10.0	12.6	10.0
Alkalinity (mg/l)	164.4	138.2	121.4	135.2
BOD_5 (mg/l)	1.1	0.9	0.8	0.7
Chloride (mg/l)	14.0	34.0	6.0	20.7
COD (mg/l)	3.9	7.4	3.6	5.9
CN (free) (mg/l)	0.032	K0.01	K0.01	0.022
Total Dissolved Solids (mg/l)	208.0	276.0	170.0	242.0
Fluoride (mg/l)	0.14	0.11	0.08	0.11
Total Hardness (mg/l)	203.6	210.4	155.6	192.0
Sulfide (mg/l)	0.3	0.9	K0.1	0.2
Phenols (mg/l)	K0.1	K0.1	K0.1	K0.1
Sulfate (mg/l)	22.3	56.5	12.6	38.4
Suspended Solids (mg/l)	11.0	10.0	12.0	11.0
NH_3-N (mg/l)	0.20	0.17	0.18	0.14
NO_2 + NO_3 - N (mg/l)	2.90	0.885	0.855	1.7
TKN (mg/l)	0.50	0.67	0.67	0.49
Phosphorous (total) (mg/l)	0.042	0.020	0.020	0.105
Phosphorous (dissolved) Ortho (mg/l)	0.016	0.020	0.004	0.093
Phthalate Esters (ug/l) (total)	47.0	4.0	90.0	1.0
Benzyl butyl phthalate (ug/l)	32.0	K1.0	9.0	K1.0
Bis (2-ethylhexyl) phthalate (ug/l)	15.0	K1.0	25.0	1.0
Bi-n-butal phthalate (ug/l)	K1.0	4.0	46.0	K1.0
Di-n-octyl phthalate (ug/l)	K1.0	K1.0	3.0	K1.0
Di-ethyl phthalate (ug/l)	K1.0	K1.0	7.0	K1.0
Di-methyl phthalate (ug/l)	K1.0	K1.0	K1.0	K1.0
Al (total)) (ug/l)	445.0	275.0	210.0	435.0
As (total) (ug/l)	1.0	1.0	1.0	2.0
Ba (total) (ug/l)	112.0	57.0	63.0	64.0
Be (total) (ug/l)	K1.0	1.0	K1.0	1.0
Cd (total) (ug/l)	3.0	2.0	2.0	2.0
Ca (total) (mg/l)	61.0	63.0	52.0	63.0
Cr (total) (ug/l)	1.0	K1.0	K1.0	K1.0
Cu (total) (ug/l)	12.0	6.0	6.0	12.0
Fe (total) (ug/l)	103.0	130.0	138.0	176.0
Pb (total) (ug/l)	12.0	13.0	17.0	14.0
Mg (total) (mg/l)	7.6	7.65	5.65	7.6
Mn (total) (ug/l)	18.0	20.0	37.0	28.0
Hg (total) (ug/l)	0.1	0.2	0.2	0.2
Ni (total) (ug/l)	3.0	K2.0	4.0	6.0
K (total) (mg/l)	1.4	1.03	1.05	1.3
Se (total) (ug/l)	1.1	K1.0	K1.0	K1.0
Ag (total) (ug/l)	K1.0	K1.0	1.0	1.0
Na (total) (mg/l)	6.6	19.0	3.15	12.9
Zn (total) (ug/l)	88.0	61.0	63.0	40.0
Al (dissolved) (ug/l)	4.0	64.0	56.0	ND
Cd (dissolved) (ug/l)	1.0	2.0	2.0	2.0
Cr (dissolved) (ug/l)	K1.0	K1.0	K1.0	K1.0
Cu (dissolved) (ug/l)	12.0	5.0	1.0	12.0
Fe (dissolved) (ug/l)	20.0	24.0	30.0	32.0
Pb (dissolved) (ug/l)	5.0	8.0	17.0	14.0
Mn (dissolved) (ug/l)	9.0	12.0	28.0	16.0
Hg (dissolved) (ug/l)	0.1	0.2	0.2	0.2
Se (dissolved) (ug/l)	K1.0	K1.0	K1.0	K1.0
Zn (dissolved) (ug/l)	ND	ND	ND	ND

K - below detection limit
ND - not determined

BIOLOGICAL EVALUATION

Biological data were collected and analyzed for the following groups of organisms: fecal coliform and fecal streptococcus bacteria, algae, macroinvertebrates and fish. Site specific data were compared with other sites sampled in the Cumberland River basin, available historical data and appropriate scientific literature regarding environmental tolerances and requirements of aquatic organisms.

It was determined that Beaver Creek supports diverse and speciose aquatic communities. A total of 192 taxa of algae were encountered, including many rare taxa and seven species previously unreported from Kentucky. Macroinvertebrates from 16 orders and 127 taxa were collected, including representatives of all functional feeding groups and tolerance categories. However, only relic shells of one species of freshwater mussel were collected. Fifteen species of fish were collected, including such sport species as rainbow trout (stocked), smallmouth bass and rock bass.

Only one station (7-1), in the vicinity of Monticello, showed fecal coliform levels above primary contact recreation standards.

Bacteria

Of the four stations sampled, one (7-1) violated the fecal coliform standard (KRS 5:031, Section 7) for primary contact recreation, while the remaining three stations had acceptable fecal coliform levels (Table 4). The fecal coliform/fecal streptococcus (FC/FS) ratios at one station indicated the fecal pollution to be animal in origin. The probable source of fecal pollution is agricultural runoff. Other potential sources of fecal pollution are septic tank runoff or direct pipe discharges to Beaver Creek and/or improperly operating wastewater treatment plants (WWTP). There were no violations of the pH standard.

The major threat to primary contact recreation in the segment is the Monticello WWTP, with a permitted discharge rate of 336,000 gpd. Based on the samples taken for pH and fecal coliform bacteria, it is recommended Beaver Creek and its tributaries be designated for primary and secondary contact recreation use. Data from this study indicate that these uses are currently occurring or are attainable with the application of appropriate point source pollution control technology.

Table 4

Date	Station/Location		FC/100 ml	FS/100 ml	FC/FS
24/June/82	7-1	Beaver Creek	1300	1600	0.8
24/June/82	7-2	Beaver Creek	90	2	-
24/June/82	7-3	Beaver Creek	210	160	1.3
24/June/82	7-4	Beaver Creek	66	2	-

Algae

The Beaver Creek system supports a diverse algal flora (Appendix C) with a total of 192 taxa encountered at the two sites investigated (7-2 and 7-3). Most species encountered were typical stream forms that exhibit a wide range of environmental tolerance; however, many rare taxa were observed, including seven species previously unreported from Kentucky. While taxa richness, diversity and equitability did not appear substantially different between stations, the community structure at each site was distinct. Station 7-2 was dominated by species associated with nutrient rich waters containing slightly elevated chloride levels, while 7-3 was characterized by typical eastern Kentucky stream species associated with high quality, well oxygenated waters. Beaver Creek appears to be a very productive stream which supports an above average number of algal taxa.

Beaver Creek

Station 7-2

The periphyton community consisted of dense growths of filamentous green and blue-green algae, as well as Melosira varians, a filamentous diatom. Planktonic algae, representative of five algal divisions, were abundant in the community. Alkaliphilous, placcoderm desmids and pennate diatoms were speciose. The abundance of attached algae, as well as the dominant species observed, suggests a moderate degree of nutrient enrichment, although values for nutrients were low at the time of sampling. The stream appeared to be very productive and supported many algal taxa (142).

The diatom community consisted of a diverse ($\bar{d}$ = 4.6632) assemblage of largely typical rheophilic stream forms (Appendix C). The community was dominated (42.5%) by four species which are generally associated with nutrient enriched streams (Lowe 1974, DES unpublished data). Those species accounted for only 2.1% of the community at the upstream site (7-3). The occurrence of abundant populations of Melosira varians (15.5%) is suggestive of elevated nitrogen levels. Cholnoky (1968) indicated that this species is probably an obligate nitrogen heterotroph. The relative abundance of Melosira at station 7-3 was 0.5%. The presence of Navicula salinarum var. intermedia (12.5% relative abundance) and Nitzschia frustulum var. perminuta (2.4%) is probably reflective of elevated chloride levels at this site, apparently due to historical oil drilling activities and storage facilities. The former species is characteristic of "water of high mineral content to brackish water" (Patrick and Reimer 1966), while the latter taxon reached abundant status in streams impacted by oil well brine (DES 1982). With the exception of those species, the diatom community consisted of a typical eastern Kentucky flora (refer to Harker et al. 1979, 1980) including several rare taxa. The occurrence of Amphora ovalis var. pediculus, Caloneis ventricosa var.

subundulata and Cymbella lata represent new collection records for Kentucky (refer to Camburn 1982). Campylodiscus noricus var. hibernica, a rare diatom, has not been reported in Kentucky for over 20 years (refer to Brohm 1963).

Beaver Creek

Station 7-3

The attached algal community was characterized by moderate to dense growths of filamentous green, blue-green, and red algae. Blue-green algae and pennate diatoms were speciose (Appendix C). The community structure was similar to that observed by Harker et al. (1979, 1980) in streams located within this region of Kentucky. Common taxa included Mougeotia species, Chaetophora, Cladophora, and Lemanea. A total of 152 algal species have been identified from this site, in addition to other unknown, and possibly undescribed, species. The abundance of taxa found here is reflective of excellent water quality conditions, as evidenced by various physicochemical parameters.

The diatom community consisted of a diverse ($\bar{d}$ = 4.0226) assemblage of typical rheophilic stream species. The community was dominated by Achnanthes and Cymbella species which are associated with well oxygenated streams (Lowe 1974). Harker et al. (1979) observed that high quality streams in eastern Kentucky were dominated by Achnanthes deflexa, which was the dominant taxon at this site. Diversity and equitability were lower here than observed at station 7-2, due to the dominance of the previously mentioned taxa. The occurrence of Achnanthes hauckiana, Achnanthes lanceolata var. omissa, Navicula dibola, and Navicula tenelloides represent new collection records for Kentucky (refer to Camburn 1982).

Macroinvertebrates

Macroinvertebrate collections were made at stations 7-2 and 7-3. A total of 16 orders and 127 taxa were collected from those locations (Appendix D).

Representatives of annelids, mollusks, crustaceans and all major groups of aquatic insects were observed at both collecting sites. Macroinvertebrates collected from both sites included those which are either intolerant, facultative or tolerant to the impacts of municipal waste, siltation and oil and gas operations. Representatives from all functional feeding groups were observed at both stations. The above reflects the good water quality and diversity of habitats found in the Beaver Creek drainage.

The speciose unionid mussel fauna reported by Wilson and Clark (1914) and Neal and Allen (1964) (38 species) from Beaver Creek near the mouth, prior to impoundment of Lake Cumberland, was absent at both sites. The impoundment of the Cumberland River eliminated this diverse mussel bed. Only relic shells of one freshwater mussel Medionidus conradicus were collected at one station (7-2) during this survey. A collection made in 1979 by Kentucky Nature Preserves Commission (unpublished data) yielded relic specimens of Ptychobranchus subtentum, Medionidus conradicus, Villosa taeniata punctata and Lampsilis fasciola. The paucity of the mussel fauna in the upper and middle portions of Beaver Creek is surprising in light of the high water quality and suitable habitat found throughout most of the stream system. However, the past oil well pollution problems discussed earlier may have eliminated the Beaver Creek fauna.

Except for the unionid mussel fauna, the macroinvertebrate species composition of Beaver Creek is similar to that of the Little South Fork of the Cumberland River, as reported by Harker et al. (1979 and 1980). This is understandable since the two stream systems lie adjacent to each other, have similar gradients and drain the same type of lithology.

Beaver Creek

Station 7-2

This station had a diversity of habitat types, including Justicia beds, undercut banks and runs and boulder/cobble riffles. Large cracks filled with gravel and fines, in the runs and edges of the Justicia beds, apparently provided additional habitat for rheophilic macroinvertebrates. The lack of suitable riffle habitat prevented quantitative macroinvertebrate sampling.

A speciose macroinvertebrate fauna (73 taxa), which included annelids, mollusks, crustaceans and all major groups of aquatic insects (Appendix D), was found at this site. The dipterans (flies) were the most diverse group and were found living in virtually all habitats. The odonate (dragonflies and damselflies) and coleopteran (beetles) faunas were also well developed, but were primarily found inhabiting the margins of the numerous Justicia beds and undercut banks. All functional feeding groups were also represented.

Organisms from all three pollution categories were observed. Data presented by Harker et al. (1979 and 1980) indicate that streams degraded by siltation do not support such a speciose macroinvertebrate fauna. In addition, any adverse effects from past oil well operations have apparently been mitigated, as reflected in the speciose macroinvertebrate community. Data from Harker et al. (1979) indicate that streams affected by oil well pollution have a general decrease in numbers and kinds of species, with the mayflies (Ephemeroptera) being particularly susceptible. Charles (1964) also noted the reduction and/or elimination of mayflies in streams impacted by oil well operations. The occurrence of seven species of mayflies is further indication of the absence of oil well pollution occurring at the time of sampling.

Beaver Creek

Station 7-3

This site had virtually all types of stream habitats. These, in conjunction with the high water quality, were primarily responsible for the highly speciose macroinvertebrate fauna (102 taxa) observed here. Annelids, mollusks, crustaceans and all major groups of aquatic insects were found, often in abundance. Organisms from all three pollution categories were observed at this location. In addition, all functional feeding groups were also observed. The dipterans (flies) were the most speciose group (24 taxa). The trichopterans (caddisflies) and ephemeropterans (mayflies) were also speciose (16 and 14 taxa respectively), and were primarily found inhabiting the riffle areas. One caddisfly Cheumatopsyche accounted for 20% of the relative abundance. Fifteen taxa of coleopterans (beetles) were found living in virtually all habitats. Two of those, Optioservus ovalis and Psephenus herricki, had relative abundance values of 29% and 21% respectively. Data presented by Sinclair (1964), Weber (1973) and Harker et al. (1979 and 1980) indicate that the three aforementioned organisms with the highest relative abundance values are either facultative or tolerant to a wide variety of environmental conditions. The $\bar{d}$ was high (3.2359) and the e was considered low (0.1970). The low e value is a reflection of the three organisms discussed above that exhibited high relative abundance values.

Fish

Beaver Creek supported a fairly diverse fish fauna, although not as speciose as adjacent Otter Creek, which was sampled for comparison. Fifteen species were collected from two stations on Beaver Creek, while 17 species were collected at one site on Otter Creek (Appendix E). Rosefin shiners Notropis ardens and stonerollers Campostoma anomalum were the most abundant species at both sites. The stream also supported a good sport fishery; rock bass Ambloplites

rupestris, smallmouth bass Micropterus dolomieui and bluegill Lepomis macrochirus were taken, along with rainbow trout Salmo gairdneri. In addition, the presence of young of the year of several species indicates spawning was occurring in the sampled areas. The fish communities at both sites were rated as good (after Karr 1981).

Rainbow trout are stocked annually in Beaver Creek by the Kentucky Department of Fish and Wildlife Resources (KDFWR) on a put and take basis. The reach from Stillhouse Hollow to Duncan Branch has been recommended for coldwater aquatic habitat. Rainbow trout were collected and observed at station 7-2 which is 8 km (5 mi) downstream of Duncan Branch. It would appear that most areas of the stream will support trout, although no reproduction has been observed. The stream also supports a sport fishery for rock bass and smallmouth bass. Fishermen were observed with a stringer of rock bass at station 7-3.

Appendix A

Site Locations and Physical Evaluation

Site No:	02007001
Stream:	Elk Spring Creek
County:	Wayne
Location:	KY 167 bridge
Latitude:	36° 49' 22"
Longitude:	84° 51' 23"
Stream Order:	III
USGS Topo Quad:	Monticello, Kentucky
DOW Map No.:	3-42
RMI:	1.8
Sampling Dates:	23-June-82
Type Sampling:	Physicochemical
Stream Gradient:	High
Pool Width:	7.6 to 12.2 m
Pool Depth:	Up to 0.3 m
Pool Substrate:	90% bedrock, 5% boulder, 5% cobble
Riffle Width:	4.6 to 6.1 m
Riffle Depth:	0.1 to .15 m
Riffle Substrate:	50% cobble, 30% pebble, 10% gravel, 5% boulder, 5% fines
Bank Height:	North - 1.2 to 2.4 m; South - 0.9 to 1.2 m
Bank Slope:	North - 40 to 60%; South - 20 to 40%
Riparian Vegetation - %	
Trees:	30
Shrubs:	20
Herbs:	50

Exposed:	0
Width:	ND
Canopy over Stream - %:	25 to 50
Bank Stability:	Excellent
Erosion:	Slight
Sedimentation:	Slight
Imbeddedness:	None
Stream Habitat:	Undercut banks, large boulders, rock ledges, submerged tree roots
Hydraulic Obstructions:	Bridge abutment
Physical Impacts:	None
Nonpoint Sources:	Pastures, row crops, scattered dwellings, KY 167

ND - Not Determined

Site Locations and Physical Evaluation

Site No:	02007002
Stream:	Beaver Creek
County:	Wayne
Location:	KY 200 bridge
Latitude:	36° 47' 50"
Longitude:	84° 53' 50"
Stream Order:	III
USGS Topo Quad:	Parnell, Kentucky
DOW Map No.:	3-41
RMI:	24.04
Sampling Dates:	23-June-82
Type Sampling:	Biological, Physicochemical
Stream Gradient:	Moderate
Pool Width:	9.1 to 15.2 m
Pool Depth:	0.15 to 1.1 m
Pool Substrate:	90% bedrock with some fine to boulder sized particles
Riffle Width:	9.1 to 12.2 m
Riffle Depth:	Up to 0.19 m
Riffle Substrate:	Cobble/boulder
Bank Height:	ND
Bank Slope:	Southwest - 50 to 70%, Northeast - 20 to 60%
Riparian Vegetation - %	
Trees:	60
Shrubs:	20
Herbs:	20

Exposed:	0
Width:	ND
Canopy over Stream - %:	25 to 50
Bank Stability:	Excellent
Erosion:	Slight
Sedimentation:	Slight
Imbeddedness:	Unimbedded
Stream Habitat:	Rock ledges, water willow beds, undercut banks, submerged tree roots, large boulders, various substrates
Hydraulic Obstructions:	Bridge abutment
Physical Impacts:	Partial channelization around bridge
Nonpoint Sources:	Scattered dwellings and office buildings, abandoned oil storage area, pastures, row crops

ND - Not Determined

Site Locations and Physical Evaluation

Site No:	02007003
Stream:	Beaver Creek
County:	Wayne
Location:	at ford off KY 167, 7.85 mi south of Monticello, KY
Latitude:	36° 44' 46"
Longitude:	84° 51' 03"
Stream Order:	III
USGS Topo Quad:	Parmleysville, Kentucky
DOW Map No.:	2-42
RMI:	32.02
Sampling Dates:	23-June-82
Type Sampling:	Biological, Physicochemical
Stream Gradient:	High
Pool Width:	9.1 to 13.7 m
Pool Depth:	0.15 to 0.8 m
Pool Substrate:	50% pebble, 20% gravel, 15% cobble, 10% fines, 5% boulder
Riffle Width:	6.1 to 7.6 m
Riffle Depth:	0.05 to 0.15 m
Riffle Substrate:	70% pebble, 15% gravel, 15% fines
Bank Height:	ND
Bank Slope:	Varied from 20 to 60%
Riparian Vegetation - %	
Trees:	70
Shrubs:	15

Herbs:	15
Exposed:	0
Width:	East - 9.1 to 15.2 m; West - 3.1 to 6.1 m
Canopy over Stream - %:	50 to 75
Bank Stability:	Excellent
Erosion:	Slight
Sedimentation:	Slight
Imbeddedness:	Unimbedded
Stream Habitat:	Undercut banks, rock ledges, submerged tree roots, logs and stumps, large boulders, various substrates
Hydraulic Obstructions:	Bridge abutment, gravel bar
Physical Impacts:	None
Nonpoint Sources:	KY 167, pastures, row crops, silviculture, residential areas

ND - Not Determined

Site Locations and Physical Evaluation

Site No:	02007004
Stream:	Beaver Creek
County:	Wayne
Location:	KY 90 bridge
Latitude:	36° 49' 03"
Longitude:	84° 52' 49"
Stream Order:	III
USGS Topo Quad:	Parnell, Kentucky
DOW Map No.:	3-41
RMI:	21.35
Sampling Dates:	24-June-82
Type Sampling:	Physicochemical
Stream Gradient:	Moderate
Pool Width:	ND
Pool Depth:	ND
Pool Substrate:	Primarily bedrock with scattered boulders and cobble
Riffle Width:	Absent
Riffle Depth:	Absent
Riffle Substrate:	Absent
Bank Height:	ND
Bank Slope:	50 to 70%
Riparian Vegetation - %	
Trees:	70
Shrubs:	20
Herbs:	10

Exposed:	0
Width:	>30 m
Canopy over Stream - %:	50 to 75
Bank Stability:	Good
Erosion:	Slight
Sedimentation:	ND
Imbeddedness:	ND
Stream Habitat:	ND
Hydraulic Obstructions:	Bridge abutment
Physical Impacts:	None
Nonpoint Sources:	KY 90, pastures, silviculture, scattered dwellings

ND - Not Determined

Appendix B

Riparian Vegetation for the
Beaver Creek Drainage

Taxa	Stations 7-2	7-3
Acer negundo (boxelder)	X	X
Acer rubra (red maple)	X	-
Acer saccharum (sugar maple)	-	X
Carex comosa (sedge)	X	-
Carex vulpinoidea (sedge)	X	X
Cercis canadensis (redbud)	X	X
Daucus carota (Queen Anne's lace)	-	X
Eleocharis obtusa (spike rush)	X	-
Equisetum arvense (horsetail)	X	-
Erigeron strigosus (fleabane)	X	-
E. sp. (fleabane)	-	X
Eupatorium sp. (Eupatorium)	X	-
Festuca arundinacea (fescue)	-	X
F. rubra (fescue)	X	-
Fraxinus sp. (ash)	-	X
Glyceria striata (manna grass)	-	X
Juglans sp. (walnut)	-	X
Juncus acuminatus (rush)	-	X
J. effusus (rush)	X	X
J. tenuis (rush)	X	-
Jussiaea repens (water primrose)	X	-
Justicia americana (water willow)	X	-
Mentha sp.	X	X
Platanus occidentalis (sycamore)	X	X
Potomogeton amplifolius (pondweed)	-	X
P. foliosus (pondweed)	-	X
Pueraria lobata (kudzu)	X	-
Quercus alba (white oak)	-	X
Robinia pseudoacacia (black locust)	X	-
Rumex crispus (curled dock)	X	-
Salix nigra (black willow)	X	-
Scirpus americanus (bulrush)	X	-
S. atrovirens (bulrush)	X	-
S. lineatus (bulrush)	-	X
Trifolium repens (white clover)	X	-
Typha latifolia (cat-tail)	X	-
Ulmus sp. (elm)	-	X
Vitis sp. (grape vine)	-	X
Total Species	24	20

Total Taxa observed: 38

Appendix C

Algal Synoptic List for the Beaver Creek System

Taxa	Station	
	7-2	7-3
Chlorophycophyta (Green Algae)		
Chaetophora incrassata	-	X
Chlamydomonas sp.	X	-
Cladophora glomerata	X	X
Closterium spp.	X	-
Cl. acerosum	X	-
Cosmarium spp.	X	-
Cylindrocapsa geminella	-	X
Mougeotia spp.	X	X
M. parvula	-	X
M. cf. varians	-	X
Oedogonium spp.	X	X
Scenedesmus sp. 1	X	X
Sc. abundans	X	-
Sc. bijuga	X	-
Sc. dimorphus	X	-
Sc. obliquus	-	X
Sc. quadricauda	X	-
Staurastrum sp.	X	X
Stigeoclonium sp.	-	X
Tetraedron lunula	X	-
green algal flagellates	X	X
Chrysophycophyta		
Chrysophyseae (Golden Algae)		
Mallomonas sp.	X	-
Bacillariophyseae (Diatoms)		
Achnanthes sp.	X	X
Ach. affinis	X	X
Ach. clevei var. rostrata	-	X
Ach. deflexa	X	X
Ach. hauckiana	-	X
Ach. lanceolata var. dubia	X	X
Ach. lanceolata var. omissa	X	X
Ach. linearis	-	X
Ach. minutissima	X	X
Amphipleura pellucida	X	X
Amphora ovalis var. affinis	-	X
Amp. ovalis var. pediculus	X	X
Amp. perpusilla	X	X
Amp. submontana	X	X
Bacillaria paradoxa	-	X
Caloneis bacillum	X	X
Cal. hyalina	-	X
Cal. ventricosa var. subundulata	X	X

Algal Synoptic List for the Beaver Creek System

Taxa	Station	
	7-2	7-3
Campylodiscus noricus var. hibernica	X	-
Cocconeis pediculus	X	X
Coc. placentula var. euglypta	X	X
Coc. placentula var. lineata	X	-
Cyclotella meneghiniana	X	X
Cymatopleura elliptica	X	X
Cy. solea	X	X
Cymbella spp.	-	X
Cym. affinis	X	X
Cym. cymbiformis	-	X
Cym. delicatula	X	X
Cym. cf. hebridica	X	-
Cym. hustedtii	X	X
Cym. lata	X	X
Cym. microcephala	X	X
Cym. minuta	X	X
Cym. prostrata	X	X
Cym. prostrata var. auerswaldii	X	X
Cym. sinuata	X	X
Cym. triangulum	X	-
Cym. tumida	X	X
Cym. turgidula	X	X
Cym. sp. 1	X	X
Cym. sp. K	X	X
Diatoma vulgare	X	X
Diploneis spp.	X	X
D. elliptica	-	X
D. subovalis	-	X
D. oblongella	X	-
Epithemia intermedia	X	X
Eunotia sp.	X	-
E. pectinalis	X	X
Fragillaria capucina var. mesolepta	-	X
Frustulia rhomboides var. amphipleuroides	X	X
F. vulgaris	X	X
Gomphonema spp.	X	X
G. abbreviatum	X	X
G. acuminatum	-	X
G. angustatum	X	X
G. angustatum var. sarcophagus	X	-
G. clevei	-	X
G. dichotomum	-	X
G. gracile	-	X
G. mehleri	X	-
G. olivaceum	X	X
G. parvulum	X	X

Algal Synoptic List for the Beaver Creek System

Taxa	Station	
	7-2	7-3
G. puiggarianum var. aequatorialis	X	X
G. sphaerophorum	X	X
G. subclavatum var. mexicanum	X	X
G. tenellum	X	X
Gyrosigma scalproides	X	X
Gyr. sciotense	X	-
Gyr. spencerii	-	X
Hantzschia amphioxys	X	X
Melosira varians	X	X
Meridion circulare	X	X
Navicula spp.	X	X
Nav. anglica var. subsalsa	X	X
Nav. angusta	-	X
Nav. bacillum	-	X
Nav. capitata	X	X
Nav. cincta	X	X
Nav. cryptocephala	X	X
Nav. cuspidata	-	X
Nav. decussis	X	-
Nav. dibola	-	X
Nav. exigua var. capitata	-	X
Nav. gottlandica	-	X
Nav. gregaria	X	-
Nav. heufleri var. leptocephala	-	X
Nav. hustedtii	X	-
Nav. lanceolata	-	X
Nav. menisculus var. upsaliensis	-	X
Nav. mutica	X	-
Nav. notha	X	-
Nav. pelliculosa	X	-
Nav. placentula	X	-
Nav. pupula	-	X
Nav. pupula var. capitata	X	-
Nav. pupula var. elliptica	-	X
Nav. pupula f. rostrata	-	X
Nav. radiosa	X	X
Nav. radiosa var. parva	X	X
Nav. radiosa var. tenella	X	X
Nav. rhynchocephala	X	X
Nav. salinarum var. intermedia	X	X
Nav. schroeteri var. escambia	X	-
Nav. secreta var. apiculata	X	X
Nav. symmetrica	X	-
Nav. tantula	X	-
Nav. tenelloides	-	X
Nav. tripunctata	X	X

Algal Synoptic List for the Beaver Creek System

Taxa	Station	
	7-2	7-3
Nav. viridula var. linearis	X	X
Neidium binode	-	X
Neid. iridis var. amphigomphus	-	X
Nitzschia spp.	X	X
Nit. acula	X	X
Nit. amphibia	X	X
Nit. angusta var. acuta	-	X
Nit. apiculata	X	X
Nit. capitellata	X	X
Nit. denticula	X	X
Nit. dissipata	X	X
Nit. fonticola	X	X
Nit. frustulum var. perminuta	X	-
Nit. gandersheimiensis	-	X
Nit. gracilis	X	X
Nit. hungarica	X	-
Nit. intermedia	X	X
Nit. linearis	X	X
Nit. lorenziana var. subtilis	-	X
Nit. microcephala	X	-
Nit. palea	X	X
Nit. paleacea	X	X
Nit. rautenbachiae	X	X
Nit. recta	X	X
Nit. romana	X	X
Nit. sigmoidea	X	X
Nit. sinuata var. tabellaria	X	X
Nit. sp. 1	-	X
Pinnularia spp.	X	X
P. biceps	-	X
P. obscura	X	-
Rhoicosphenia curvata	X	X
Stauroneis smithii	-	X
Stephanodiscus sp. ?	X	X
Surirella sp.	X	-
Sur. angusta	X	X
Sur. linearis var. helvetica	X	X
Sur. ovata	X	X
Sur. ovata var. salina	X	X
Sur. stalagma	-	X
Sur. tenera var. nervosa	X	X
Synedra parasitica	X	-
Syn. rumpens var. fragillarioides	-	X
Syn. ulna	X	X

Algal Synoptic List for the Beaver Creek System

Taxa	Station	
	7-2	7-3
Euglenophycophyta (Euglenoid Algae)		
Characium falcatum	X	-
Trachelomonas sp.	-	X
Rhodophycophyta (Red Algae)		
Lemanea australis	-	X
Cyanochloronta (Blue-green Algae)		
Agmenellum thermale	X	X
Agm. quadruplicatum	X	X
Anabaina oscillarioides	X	X
Calothrix parietina	X	X
Dactylococcopsis fascicularis	X	X
Entophysalis lemaniae	-	X
Gomphosphaeria lacustris	X	-
Microcoleus lyngbyaceous	-	X
M. vaginatus	X	-
Oscillatoria lutea	X	-
Porphyrosiphon miniatus	-	X
Schizothrix calcicola	X	X
Sch. mexicana	X	X
Total Taxa:	142	152

Total Taxa observed in study: 192

Diatom Species Proportional Count for
Station 7-2, Beaver Creek

Taxa	Relative Abundance
Melosira varians	15.5%
Navicula salinarum var. intermedia	12.5%
Cymbella prostrata var. auerswaldii	8.0%
Cocconeis pediculus	6.9%
Navicula tripunctata	6.5%
Achnanthes minutissima	5.6%
Achnanthes deflexa	5.3%
Cymbella affinis	4.5%
Navicula cryptocephala	2.7%
Cymbella delicatula	2.4%
Cymbella minuta	2.4%
Navicula radiosa var. tenella	2.4%
Nitzschia frustulum var. perminuta	2.4%
Gomphonema parvulum	1.7%
Synedra ulna	1.4%
Cocconeis placentula var. euglypta	1.2%
Cymbella sp. K	1.2%
Gomphonema tenellum	1.2%
Nitzschia amphibia	1.1%
Nitzschia linearis	1.1%
Nitzschia sinuata var. tabellaria	1.1%
Nitzschia denticula	0.9%
Nitzschia apiculata	0.6%
Nitzschia dissipata	0.6%
Nitzschia fonticola	0.6%
Surirella ovata	0.6%
Achnanthes sp.	0.5%
Achnanthes affinis	0.5%
Achnanthes lanceolata var. dubia	0.5%
Amphora perpusilla	0.5%
Cymbella sinuata	0.5%
Diatoma vulgare	0.5%
Gomphonema spp.	0.5%
Gomphonema olivaceum	0.5%
Navicula gregaria	0.5%
Navicula radiosa var. parva	0.5%
Navicula secreta var. apiculata	0.5%
Nitzschia paleacea	0.5%
Cyclotella meneghiniana	0.3%
Cymbella turgidula	0.3%
Navicula radiosa	0.3%
Nitzschia spp.	0.3%
Surirella linearis var. helvetica	0.3%
Cymatopleura solea	0.2%
Cymbella hustedtii	0.2%
Cymbella lata	0.2%
Cymbella prostrata	0.2%

Diatom Species Proportional Count for Station 7-2, Beaver Creek

Taxa	Relative Abundance
Diploneis sp.	0.2%
Epithemia intermedia	0.2%
Navicula mutica	0.2%
Navicula notha	0.2%
Navicula pupula var. capitata	0.2%
Navicula schroeteri var. escambia	0.2%
Nitzschia acula	0.2%
Nitzschia capitellata	0.2%
Nitzschia hungarica	0.2%
Nitzschia lorenziana var. subtilis	0.2%
Nitzschia palea	0.2%
Nitzschia rautenbachiae	0.2%
Pinnularia obscura	0.2%
Rhoicosphenia curvata	0.2%
Surirella ovata var. salina	0.2%
Diversity ($\bar{d}$)	4.6632
Equitability (e)	0.6060

Diatom Species Proportional Count for Station 7-3, Beaver Creek

Taxa	Relative Abundance
Achnanthes deflexa	25.2%
Achnanthes minutissima	23.0%
Cocconeis pediculus	12.7%
Cymbella microcephala	6.8%
Cymbella hustedtii	1.9%
Cocconeis placentula var. euglypta	1.7%
Gomphonema clevei	1.7%
Navicula salinarum var. intermedia	1.3%
Achnanthes linearis	1.1%
Cymbella delicatula	1.1%
Navicula menisculus var. upsaliensis	1.1%
Achnanthes lanceolata var. dubia	0.9%
Cymbella affinis	0.9%
Gomphonema tenellum	0.9%
Achnanthes affinis	0.8%
Navicula cryptocephala	0.8%
Nitzschia amphibia	0.8%
Nitzschia dissipata	0.8%
Achnanthes spp.	0.6%
Cymbella sp. K	0.6%
Navicula lanceolata	0.6%
Nitzschia spp.	0.6%
Nitzschia acula	0.6%
Nitzschia recta	0.6%
Amphora submontana	0.5%
Caloneis bacillum	0.5%
Diploneis spp.	0.5%
Melosira varians	0.5%
Navicula radiosa var. tenella	0.5%
Nitzschia rautenbachiae	0.5%
Surirella angusta	0.5%
Synedra rumpens var. fragillarioides	0.5%
Achnanthes lanceolata var. omissa	0.3%
Amphora perpusilla	0.3%
Bacillaria paradoxa	0.3%
Cymbella minuta	0.3%
Cymbella prostrata	0.3%
Cymbella prostrata var. auerswaldii	0.3%
Cymbella sinuata	0.3%
Epithemia intermedia	0.3%
Gomphonema spp.	0.3%
Gomphonema gracile	0.3%
Gomphonema puiggarianum var. aequatorialis	0.3%
Navicula menisculus var. upsaliensis	0.3%
Nitzschia denticula	0.3%
Nitzschia intermedia	0.3%
Nitzschia linearis	0.3%

Diatom Species Proportional Count for Station 7-3, Beaver Creek

Taxa	Relative Abundance
Nitzschia lorenziana var. subtilis	0.3%
Nitzschia palea	0.3%
Pinnularia spp.	0.3%
Rhoicosphenia curvata	0.3%
Surirella linearis var. helvetica	0.3%
Cymatopleura solea	0.2%
Cymbella sp.	0.2%
Gomphonema abbreviatum	0.2%
Gomphonema sphaerophorum	0.2%
Gyrosigma spencerii	0.2%
Navicula angusta	0.2%
Navicula bacillum	0.2%
Navicula secreta var. apiculata	0.2%
Navicula tenelloides	0.2%
Neidium binode	0.2%
Nitzschia apiculata	0.2%
Nitzschia paleacea	0.2%
Nitzschia romana	0.2%
Surirella ovata	0.2%
Surirella tenera var. nervosa	0.2%
Diversity ($\bar{d}$)	4.0226
Equitability (e)	0.3546

Appendix D

Macroinvertebrate Synoptic List for the Beaver Creek Drainage

Taxa	Stations 7-2	Stations 7-3
Haplotaxida		
Tubificidae		
Tubifex-Limnodrilus gp.	X	X
Lumbriculida		
Lumbriculidae		
Lumbriculus sp.	-	X
Basommatophora		
Ancylidae		
Ferrissia rivularis	X	X
Physidae		
Physella integra (?)	X	X
Planorbidae		
Helisoma sp.	-	X
Mesogastropoda		
Pleuroceridae		
Elimia ebenum	X	X
Elimia plicata-striata	X	X
Heterodonta		
Corbiculidae		
Corbicula fluminea	X	-
Sphaeriidae		
Pisidium sp.	X	X
Sphaerium simile	X	X
Sphaerium striatinum	-	X
Schizodonta		
Unionidae		
Medionidus conradicus	X	-
Amphipoda		
Gammaridae		
Crangonyx sp.	-	X
Decapoda		
Cambaridae		
Cambarus cumberlandensis	-	X
Cambarus sp.	X	-
Orconectes putnami	X	X
Ephemeroptera		
Baetidae		
Baetis sp.	X	X
Cloeon sp.	-	X
Caenidae		
Caenis sp.	X	X
Ephemeridae		
Ephemera varia	X	X
Hexagenia limbata	-	X
Ephemerellidae		
Dannella lita	-	X
Ephemerella sp.	-	X

Macroinvertebrate Synoptic List for the
Beaver Creek Drainage

Taxa	Stations 7-2	Stations 7-3
Eurylophella temporalis gp.	X	X
Heptageniidae		
Heptagenia sp.	X	X
Stenacron interpunctatum	-	X
Stenonema femoratum	-	X
Stenonema integrum	-	X
Stenonema mediopunctatum	-	X
Stenonema terminatum (?)	-	X
Stenonema sp.	X	-
Oligoneuriidae		
Isonychia sp.	X	-
Odonata		
Calopterygidae		
Calopteryx sp.	X	X
Coenagrionidae		
Argia bipunctulata	-	X
Argia sp.	X	-
Enallagma sp.	X	X
Aeschnidae		
Basiaeschna janata	X	X
Boyeria vinosa	X	X
Gomphidae		
Dromogomphus spinosus	X	X
Dromogomphus spoliatus	X	-
Hagenius brevistylus	X	-
Lanthus albistylus	X	X
Ophiogomphus mainensis	-	X
Libellulidae		
Perithemis sp.	X	X
Plecoptera		
Leuctridae		
Leuctra sp.	-	X
Perlidae		
Acroneuria abnormis	-	X
Acroneuria sp. 1	-	X
Acroneuria sp.	X	-
Perlesta placida	X	-
Phasganophora capitata	X	X
Hemiptera		
Belostomatidae		
Belostoma fluminea	-	X
Gerridae		
Gerris sp.	X	X
Trepobates sp.	X	X
Veliidae		
Microvelia americana	X	-
Rhagovelia obesa	X	-

Macroinvertebrate Synoptic List for the Beaver Creek Drainage

Taxa	Stations 7-2	Stations 7-3
Coleoptera		
Dytiscidae		
Hydroporus sp. 1	-	X
Hydroporus sp. 2	-	X
Hydroporus sp. 3	-	X
Hydroporus sp. 4	-	X
Gyrinidae		
Gyrinus sp.	-	X
Haliplidae		
Peltodytes duodecimpunctatus	-	X
Peltodytes sp.	X	-
Dryopidae		
Helichus basalis	X	X
Helichus fastigiatus	X	-
Helichus lithophilus	X	X
Elmidae		
Dubiraphia quadrinotata	X	X
Macronychus glabratus	X	X
Optioservis ovalis	X	X
Stenelmis crenata	X	X
Hydrophilidae		
Berosus sp.	X	-
Helophorus sp.	-	X
Psephenidae		
Ectopria nervosa	-	X
Psephenus herricki	X	X
Megaloptera		
Corydalidae		
Corydalus cornutus	X	X
Nigronia serricornis	X	X
Sialidae		
Sialis sp.	X	X
Diptera		
Empididae		
Hemerodromia sp.	-	X
Tabanidae		
Chrysops sp.	X	-
Tabanus sp.	-	X
Chironomidae		
Ablabesmyia mallochi	X	-
Brillia flavifrons	-	X
Cladotanytarsus sp.	X	-
Crytochironomus fulvus gp.	X	X
Eukiefferiella bavarica gp.	-	X
Microtendipes sp.	-	X
Nanocladius rectinervis	X	-
Nanocladius sp.	-	X

Macroinvertebrate Synoptic List for the Beaver Creek Drainage

Taxa	Stations 7-2	Stations 7-3
Parametriocnemus lundbecki	-	x
Paratendipes albimanus	X	X
Phaenopsectra sp.	X	-
Polypedilum aviceps	-	X
Polypedilum convictum	-	X
Polypedilum fallax gp.	-	X
Polypedilum illinoense	X	X
Polypedilum scalaenum	-	X
Procladius sublettei	X	X
Stictochironomus devinctus	-	X
Stictochironomus sp.	X	-
Tanytarsus coffmani	X	-
Tanytarsus glabrascens	X	-
Tanytarsus guerlus gp.	X	X
Tanytarsus sp.	-	X
Thienemannimyia sp.	X	X
Tribelos jucundus	X	X
Tribelos fuscicornis (?)	X	-
Dixidae		
Dixella sp.	-	X
Simuliidae		
Simulium sp.	-	X
Tipulidae		
Hexatoma sp.	-	X
Tipula strepens	X	X
Trichoptera		
Glossosomatidae		
Agapetus sp.	-	X
Glossosoma sp.	-	X
Helicopsychidae		
Helicopsyche borealis	X	X
Hydropsychidae		
Cheumatopsyche sp.	X	X
Hydropsyche betteni gp.	X	X
Hydropsyche sp. 1	-	X
Symphitopsyche slossonae	-	X
Symphitopsyche sparna	X	X
Hydroptilidae		
Hydroptila sp.	-	X
Orthotrichia sp.	X	X
Leptoceridae		
Ceraclea sp.	-	X
Limnephilidae		
Goera sp.	-	X
Neophylax sp.	-	X
Pynopsyche sp.	-	X
Phylopotamidae		
Chimarra atterrima	-	X

Macroinvertebrate Synoptic List for the Beaver Creek Drainage

Taxa	Stations 7-2	Stations 7-3
Polycentropodidae		
Cyrnellus fraternus	-	X
Polycentropus sp.	-	X
Rhyacophilidae		
Rhyacophila fuscula	X	-
Total of Taxa	73	102

Total of Taxa observed in this study: 127

Macroinvertebrate Qualitative Data for Beaver Creek at Station 7-2

Taxa	Qualitative
Haplotaxida	
Tubificidae	
Tubifex-Limnodrilus gp.	3
Basommatophora	
Ancylidae	
Ferrissia rivularis	2
Physidae	
Physella integra (?)	4
Mesogastropoda	
Pleuroceridae	
Elimia ebenum	38
Elimia plicata-striata	20
Heterodonta	
Corbiculidae	
Corbicula fluminea	1
Sphaeriidae	
Pisidium sp.	1
Sphaerium simile	5
Schizodonta	
Unionidae	
Medionidus conradicus	3
Decapoda	
Cambaridae	
Cambarus sp.	2
Orconectes putnami	28
Ephemeroptera	
Baetidae	
Baetis sp.	14
Caenidae	
Caenis sp.	1
Ephemeridae	
Ephemera varia	14
Ephemerellidae	
Eurylophella temporalis gp.	42
Heptageniidae	
Heptagenia sp.	12
Stenonema sp.	12
Oligoneuriidae	
Isonychia sp.	4
Odonata	
Calopterygidae	
Calopteryx sp.	7
Coenogrionidae	
Argia sp.	9
Enallagma sp.	7

Macroinvertebrate Qualitative Data for
Beaver Creek at Station 7-2

Taxa	Qualitative
Aeschnidae	
Basiaeschna janata	2
Boyeria vinosa	35
Gomphidae	
Dromogomphus spinous	20
Dromogomphus spoliatus	1
Hagenius brevistylus	6
Lanthus albistylus	9
Libellulidae	
Perithemis sp.	1
Plecoptera	
Perlidae	
Acroneuria sp.	5
Perlesta placida	7
Phasganophora capitata	1
Hemiptera	
Gerridae	
Gerris sp.	5
Trepobates sp.	1
Veliidae	
Microvelia americana	2
Rhagovelia obesa	4
Coleoptera	
Haliplidae	
Peltodytes sp.	1
Dryopidae	
Helichus basalis	7
Helichus fastigiatus	2
Helichus lithophilus	37
Elmidae	
Dubiraphia quadrinotata	18
Macronychus glabratus	1
Optioservus ovalis	7
Stenelmis crenata	11
Hydroptilidae	
Berosus sp.	3
Psephenidae	
Psephenus herricki	2
Megaloptera	
Corydalidae	
Corydalus cornutus	7
Nigronia serricornis	5
Sialidae	
Sialis sp.	1

Macroinvertebrate Qualitative Data for Beaver Creek at Station 7-2

Taxa	Qualitative
Diptera	
Tabanidae	
Chrysops sp.	1
Chironomidae	
Ablabesmyia mallochi	1
Cladotanytarsus sp.	8
Crytochironomus fulvus gp.	8
Microtendipes caelum	4
Nanocladius rectinervis	1
Paratendipes albimanus	7
Phaenopsectra sp.	14
Polypedilum halterale	2
Polypedilum illinoense	1
Procladius sublettei	6
Stictochironomus sp.	2
Tanytarsus coffmani	1
Tanytarsus glabrascens	3
Tanytarsus guerlus gp.	3
Thienemannimyia sp.	1
Tribelos jucundus	5
Tribelos fuscicornis (?)	7
Tipulidae	
Tipula strepens	1.
Trichoptera	
Helicopsychidae	
Helicopsyche borealis	3
Hydropsychidae	
Cheumatopsyche sp.	57
Hydropsyche betteni gp.	36
Symphitopsyche sparna	2
Hydroptilidae	
Orthotrichia sp.	2
Rhyacophilidae	
Rhyacophilia fuscula	3

Total Number of Taxa - 73
Species Diversity ($\bar{d}$) - ND
Equitability (e) - ND

Note: No quantitative sampling was conducted due to lack of suitable habitat.

ND - Not Determined

Macroinvertebrate Quantitative and Qualitative Data and Relative Abundance (RA) for Beaver Creek at Station 7-3

Taxa	Qual	Quantitative 1	2	3	Tot	RA(%)
Haplotaxida						
Tubificidae						
Tubifex-Limnodrilus gp.	2	1	2	4	6	< 1
Lumbriculida						
Lumbriculidae						
Limbriculus sp.	1	2	7	2	11	< 1
Basommatophora						
Ancylidae						
Ferrissia rivularis	1	1	-	-	1	< 1
Physidae						
Physella integra	8	2	-	-	2	< 1
Planorbidae						
Helisoma sp.	1	1	-	-	1	< 1
Mesogastropoda						
Pleuroceridae						
Elimia ebenum	200	89	92	46	227	6
Elimia plicata-striata	19	1	-	-	1	< 1
Heterodonta						
Sphaeriidae						
Pisidium sp.	5	1	-	1	2	< 1
Sphaerium simile	11	71	16	20	107	3
Sphaerium striatimum	-	-	-	1	1	< 1
Amphipoda						
Gammaridae						
Crangonyx sp.	1	-	-	-	-	-
Decapoda						
Cambaridae						
Cambarus cumberlandensis	1	3	-	-	3	< 1
Orconectes putnami	11	2	1	1	4	< 1
Ephemeroptera						
Baetidae						
Baetis sp.	9	8	8	8	24	< 1
Cloeon sp.	3	-	-	-	-	-
Caenidae						
Caenis sp. *	-	-	1	-	1	< 1
Ephemeridae						
Ephemera varia	-	-	-	2	2	< 1
Hexagenia limbata	6	-	-	-	-	-
Ephemerellidae						
Dannella lita	1	-	-	-	-	-
Ephemerella sp.	1	32	27	28	87	2
Eurylophella temporalis gp.	11	-	1	-	1	< 1
Heptageniidae						
Heptagenia sp.	3	38	49	48	135	3
Stenacron interpunctatum	4	-	-	-	-	-

Macroinvertebrate Quantitative and Qualitative Data and Relative Abundance (RA) for Beaver Creek at Station 7-3

Taxa	Qual	Quantitative 1	2	3	Tot	RA(%)
Stenonema femoratum	1	-	-	-	-	-
Stenonema integrum	-	-	-	1	1	< 1
Stenonema mediopunctatum	-	2	3	2	7	< 1
Stenonema terminatum (?)	8	24	18	25	67	2
Oligoneuriidae						
Isonychia sp.	-	12	22	12	46	1
Odonata						
Calopterygidae						
Calopteryx sp.	2	-	-	-	-	-
Coenagrionidae						
Argia bipunctulata	11	-	-	-	-	-
Enallagma sp.	10	-	-	-	-	-
Aeschnidae						
Basiaeschna janata	1	-	-	-	-	-
Boyeria vinosa	17	1	-	-	1	< 1
Gomphidae						
Dromogomphus spinosus	2	-	-	-	-	-
Lanthus albistylus	5	-	-	-	-	-
Ophiogomphus mainensis	-	24	12	18	54	1
Libellulidae						
Perithemis sp.	2	-	-	-	-	-
Plecoptera						
Leuctridae						
Leuctra sp.	-	-	9	2	11	< 1
Perlidae						
Acroneuria abnormis	3	34	27	22	83	2
Acroneuria sp. 1	-	-	5	-	5	< 1
Phasganophora capitata	1	16	7	8	31	< 1
Hemiptera						
Belostomatidae						
Belostoma fluminea	3	-	-	-	-	-
Gerridae						
Gerris remigis	1	-	-	-	-	-
Trepobates sp.	1	-	-	-	-	-
Coleoptera						
Dytiscidae						
Hydroporus sp. 1	1	-	-	-	-	-
Hydroporus sp. 2	5	-	-	-	-	-
Hydroporus sp. 3	4	-	-	-	-	-
Hydroporus sp. 4	1	-	-	-	-	-
Gyrinidae						
Gyrinus sp.	4	1	-	-	1	< 1
Haliplidae						
Peltodytes duodecimpunctatus	1	-	-	-	-	-
Dryopidae						
Helichus basalis	3	-	-	-	-	-

Macroinvertebrate Quantitative and Qualitative Data and Relative Abundance (RA) for Beaver Creek at Station 7-3

Taxa	Qual	Quantitative 1	2	3	Tot	RA(%)
Helichus lithophilus	11	-	-	-	-	-
Elmidae						
Dubiraphia quadrinotata	22	-	-	-	-	-
Macronychus glabratus	3	-	-	-	-	-
Optioservus ovalis	5	406	486	257	1149	29
Stenelmis crenata	1	-	2	3	5	< 1
Hydrophilidae						
Helophorus sp.	1	-	-	-	-	-
Psephenidae						
Ectopria nervosa	2	2	-	1	3	< 1
Psephenus herricki	7	419	262	161	842	21
Megaloptera						
Corydalidae						
Corydalus cornutus	-	-	2	-	2	< 1
Nigronia serricornis	-	15	13	16	44	1
Sialidae						
Sialis sp.	17	-	-	-	-	-
Diptera						
Empididae						
Hemerodromia sp.	-	3	11	4	18	< 1
Tabanidae						
Tabanus sp.	-	1	1	2	4	< 1
Chironomidae						
Brillia flavifrons	-	-	-	1	1	< 1
Cryptochironomus fulvus gp.	-	-	3	-	3	< 1
Eukiefferiella bavarica gp.	-	1	-	1	2	< 1
Microtendipes sp.	2	-	1	1	2	< 1
Nanocladius sp.	-	-	1	1	2	< 1
Parametriocnemus lundbecki	-	1	1	2	4	< 1
Paratendipes albimanus	9	-	-	-	-	-
Polypedilum aviceps	-	-	2	-	2	< 1
Polypedilum convictum	-	-	6	3	9	< 1
Polypedilum fallax gp.	1	-	-	-	-	-
Polypedilum illinoense	6	-	-	-	-	-
Polypedilum scalaenum	-	-	2	-	2	< 1
Procladius sublettei	1	-	-	-	-	-
Stictochironomus devinctus	-	2	-	1	3	< 1
Tanytarsus guerlus gp.	-	1	-	2	3	< 1
Tanytarsus sp.	-	-	2	-	2	< 1
Thienemannimyia sp.	1	1	-	2	3	< 1
Tribelos jucundus	16	-	-	1	1	< 1
Dixidae						
Dixella sp.	2	-	-	-	-	-
Simuliidae						
Simulium sp.	-	-	1	-	1	< 1

Macroinvertebrate Quantitative and Qualitative Data and Relative Abundance (RA) for Beaver Creek at Station 7-3

Taxa	Qual	Quantitative 1	2	3	Tot	RA(%)
Tipulidae						
Hexatoma sp.	1	-	-	3	3	< 1
Tipula strepens	-	1	-	1	2	< 1
Trichoptera						
Glossosomatidae						
Agapetus sp.	-	1	-	-	1	< 1
Glossosoma sp.	-	-	2	4	6	< 1
Helicopsychidae						
Helicopsyche borealis	4	36	46	2	84	2
Hydropsychidae						
Cheumatopsyche sp.	7	183	373	224	780	20
Hydropsyche betteni gp.	12	3	8	4	15	< 1
Hydropsyche sp. 1	-	-	-	2	2	< 1
Symphitopsyche slossonae	1	-	1	-	1	< 1
Symphitopsyche sparna	-	-	2	2	4	< 1
Hydroptilidae						
Hydroptila sp.	-	1	-	-	1	< 1
Leptoceridae						
Ceraclea sp.	1	-	-	-	-	-
Limnephilidae						
Goera sp.	4	4	3	2	9	< 1
Neophylax sp.	8	1	-	-	1	< 1
Pycnopsyche sp.	2	-	-	-	-	-
Philopotamidae						
Chimarra atterrima	-	1	-	-	1	< 1
Polycentropodidae						
Cyrnellus fraternus	1	-	-	-	-	-
Polycentropus sp.	2	-	-	1	1	< 1
Total					3941	

Total Number of Taxa - 102
Species Diversity ($\bar{d}$) - 3.2359
Equitability (e) - 0.1970

*exuviae only - not used in calculating RA, $\bar{d}$ and e.

Appendix E

Fish Synoptic List for Beaver and Otter Creeks

Taxa		Stations		
		Otter Creek	Beaver Creek	Beaver Creek
		6-1	7-2	7-3
Family	Salmonidae			
	Salmo gairdneri rainbow trout	-	1	-
Family	Cyprinidae			
	Campostoma anomalum central stoneroller	14	77	12 (6 Y)
	Hybopsis amblops bigeye club	4	-	-
	Nocomis effusus redtail chub	2	-	-
	Notropis ardens rosefin shiner	4	51	79
	Notropis chrysocephalus striped shiner	8	-	-
	Notropis galacturus whitetail shiner	1	-	-
	Notropis telescopus telescope shiner	62	-	-
	Pimephales notatus bluntnose minnow	-	26	1
	Semotilus atromaculatus creek chub	-	-	4 Y
Family	Catostomidae			
	Hypentelium nigricans northern hog sucker	-	1 Y	-
Family	Cyprinodontidae			
	Fundulus catenatus northern studfish	4	1	-
Family	Centrarchidae			
	Ambloplites rupestris rock bass	-	2	3
	Lepomis macrochirus bluegill	-	3	1
	Lepomis megalotis longear sunfish	1	9	-
	Micropterus dolomieui smallmouth bass	-	2	1
	Micropterus punctulatus spotted bass	3	-	-

Fish Synoptic List for Beaver and Otter Creeks

Taxa		Stations		
		Otter Creek	Beaver Creek	Beaver Creek
		6-1	7-2	7-3
Family	Percidae			
	Etheostoma atripinne cumberland snubnose darter	10	-	-
	Etheostoma blennioides greenside darter	5	4	1
	Etheostoma caeruleum rainbow darter	8	-	1
	Etheostoma obeyense barcheek darter	1	14	7
	Etheostoma rufilineatum redline darter	11	-	-
	Etheostoma sp. unidentified darters	-	38 Y	15 Y
	Percina caprodes logperch	2	-	-
Family	Cottidae			
	Cottus carolinae banded sculpin	11	-	-
Total Individuals		151	229	125
Total Species		17	12	10

Y = Young of Year

Appendix F

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